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The Sanitary Conditions and Necessities of School-Houses and School-Life.

American Public Health Association

LOMB PRIZE ESSAY

THE SANITARY CONDITIONS AND NECESSITIES OF SCHOOL-HOUSES AND SCHOOL LIFE

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INTRODUCTION.

As the result of prizes offered by Mr. Henry Lomb, of Rochester, N. Y., through the American Public Health Association, the following awards were made at the last meeting of the association:

I. Healthy Homes and Foods for the Working Classes. By Victor C. Vaughan, M. D., Ph. D., Professor in University of Michigan. Prize, . . $200

II. The Sanitary Conditions and Necessities of School-Houses and School-Life. By D. F. Lincoln, M. D., Boston, Mass. Prize, . . . $200

III. Disinfection and Individual Prophylaxis against Infectious Diseases. By George M. Sternberg, M. D., Major and Surgeon U. S. Army. Prize, ... $500

IV. The Preventable Causes of Disease, Injury, and Death in American Manufactories and Workshops, and the Best Means and Appliances for Preventing and Avoiding them. By George H. Ireland, Springfield, Mass. Prize, ... $200

That these essays may be placed in the hands of every family in the country is the earnest desire of the association, as well as the heartfelt wish of the public-spirited and philanthropic citizen whose unpretentious generosity and unselfish devotion to the interests of humanity have given us these essays, but the financial inability of the association renders it impossible to distribute them gratuitously;—therefore a price covering the cost has been placed upon these publications. It is to be hoped, however, that government departments, state and local boards of health, sanitary and benevolent associations, etc., will either publish these essays, or purchase editions at cost of the association, for distribution among the people.

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SCHOOL HYGIENE.

INTRODUCTORY.

Two men should be mentioned at the head of an essay of this sort, as deserving to represent the beginning of the "movement" in school hygiene. They are Cohn of Breslau, whose examinations of the eyes of school-children made a very powerful impression on the public mind some sixteen years ago, and Virchow, whose official report to the Prussian minister of education (published in 1869), is the most prominent document that can be referred to as leading the way in reform.

It is not intended in this essay to quote largely from German authorities. The mere statement of principles and facts must suffice in so wide and manifold a subject as the present.

It should be noted that Virchow makes use of the expression "school-diseases." He is probably entitled to the credit of inventing the word. In the list which he gives there is one affection which we need not dwell upon, namely, nose-bleed. In regard to another,—tubercular consumption,—there is perhaps a deficiency of evidence as to its causation in schools in America, though there can be no reasonable doubt that it is so caused, and the writer has the highest American authority for saying so.

Deformity of the spine (lateral curvature) is probably not so common by a good deal in America as Guillaume represents it in Switzerland. We lack decided evidence; but it is spoken of under the proper heads in this essay.

It remains to note the division of the subject which has been followed, viz.:

1. Site of the School-House.
2. Plan and Arrangement of the Building.
3. Ventilation and Heating.
4. Sewerage.
5. Hygiene of the Eye.
6. School-Desks and Gymnastics.
7. Affections of the Nervous System.
8. Contagious Disease.
9. Sanitary Supervision.

I. SITE.

In choosing the site for a school-building, we should take into account a number of things which might be overlooked in the case of an ordinary building. Dampness and malaria are of course fatal to a site for any purpose. For schools we must plan to have abundant light (much more than will suffice for dwellings and shops), and to have the sun's direct

rays enter each room at some time of the day. The business of the school requires the absence of noise,—a point which may be overlooked in business edifices; and the social character of the neighborhood, and its moral nuisances, are also to be considered.

Dampness. Without going much into details, the use of some method of drainage and of some shield against incoming water is suggested, as likely to be needed in many places. The cellar, as hygienists know, ought to be carefully guarded from contamination of soil and air, and should at all times be dry. Grading will suffice to keep off most of the surface water. Underground water may be provided for by a ditch, dug outside of the foundation and reaching deeper than the cellar floor, and either laid with drain tile, or filled to the depth of a foot with loose stones, after which earth is thrown in. A similar trench may be cut in the floor. All such drains are to be led to a proper place for discharge. The floor may be made damp-proof, according to Col. Waring's suggestion, by six inches of well rammed clay, or by asphalt between two layers of cement; the foundation walls may be protected by a coating of asphalt outside. A damp-proof course of asphalt in the walls above the ground is useful in preventing moisture from rising.

Small country schools, if without a cellar, should at least have an air-space underneath the floor, with a few openings in the underpinning, to give ventilation to the space.

River bottoms, places where mist is often seen, and the neighborhood of ponds, are undesirable places for building. No business is more interfered with by noise than that of school. The neighborhood of large factories, saw-mills, foundries, railway stations, engine-houses, or police stations, is therefore to be avoided. There need be no excuse for placing a school-house near any such of the latter as are under public control, or for utilizing a town lot by putting engine-houses, school-houses, and a police station, in close neighborhood. Regard ought to be had for the probable growth of a city, and avenues likely to become main lines of travel should be avoided. These things are mentioned because they are sometimes strangely disregarded. In large cities it is next to impossible to procure sites which fully satisfy the demand of hygiene in respect to the supply of light. Corner lots are enormously expensive, besides being noisy. The *Sanitary Engineer* prize designs for public schools, published in 1880, are instructive as showing that in the opinion of the prize committee,—

"The most essential thing in a public school is sufficient light. The conditions imposed in this competition make it impossible to secure this light without either overcrowding of class-rooms, or an unsatisfactory arrangement of corridors, stairs, etc."

"Upon so restricted a site as that contemplated[1], light can best be secured by making the building very high, higher than for other reasons is desirable.

[1] "A lot fronting north, of 100 feet front and 100 deep, and enclosed by buildings on adjoining lots at the sides and rear, of average city height, say four stories." (Advertisement.)

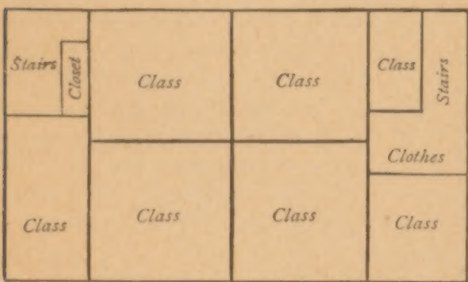
"It should be distinctly understood that the committee do not recommend the plans to which they have given awards as being the best designs for a school building, but only as the best plans for a school building to be built in a huge box, lacking one side and without a top, the sides of which box are about sixty feet high, which seem to be the conditions under which school buildings have been erected in New York, and in which from 1,500 to 2,500 children have been crowded."—(*San. Engineer*, March 1, 1880.)

The evil complained of is a general one. New York is not the only city where fine new school buildings are erected, with a pleasant outlook all around, only to have four-story houses placed on both sides, within a dozen feet of their windows, in the course of a year or two. This is one of the worst failings of city schools.

II. PLAN AND ARRANGEMENT.

Many of our oldest school buildings are extremely faulty. In fact, we have seen two reformations in school architecture, one dating from the publication of Henry Barnard's work, in 1839, while the other is now taking place. The progress made within a few years past has been as great as at any other period, and types of edifices, which were unchallenged models of excellence fifteen years ago, are now superseded.

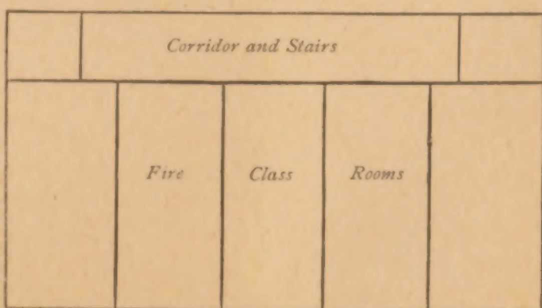
Fig. 1.



Plan of School-house illustrating excessive compactness.

In schools containing several rooms, one of the commonest faults used to be the parsimony of space, which cut down the room for entries to a minimum, and packed class-room behind class-room without breathing space. The effect of this was greatly to restrict natural ventilation. Glass sliding doors were very popular: it may be feared that they still are in some places. Spiral stairs were admired. Architectural features, such as colonnades and heavy Greek entablatures, are still seen on some older buildings, the former serving to cut off a certain part of the light, the latter taking

Fig. 2.



Plan—Same fault.

up space in the wall which ought to be devoted to windows. Excessive height is a fault which is only just beginning to be remedied. It arises partly from a false taste in architectuie, partly from the expensiveness of land in cities.

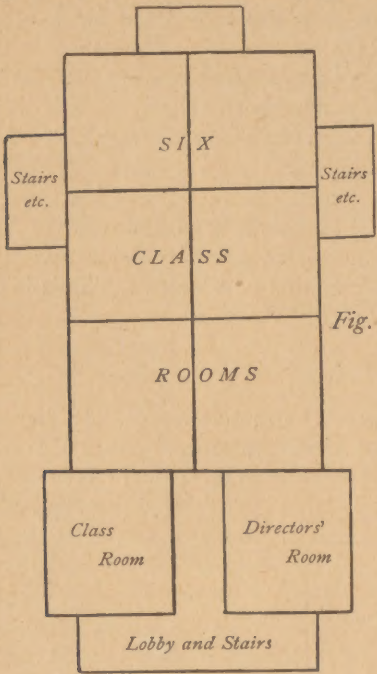


Fig. 3.

Plan of School. Philadelphia.

An instance of the excessively compact style of building is given in the illustrations (Figs. 1 and 2), which are taken from the Report of the New York State Board of Health for 1881; also in Fig. 3.

Glass sliding doors are supposed to assist in lighting rooms which are faultily lighted in other respects. They are far less effectual than is thought. A person standing in the inner room looks out through the glass doors upon well lighted rooms, and thinks the light he sees is entering the room where he stands—a false impression, which should be corrected by looking the other way. Light thus transmitted is nearly horizontal in direction, and has very little effect in brightening the page of a a book lying on a desk. Glass also reflects some light, and absorbs some. In short, light thus obtained is not good light for the purposes of study. The rooms in Fig. 3 have glass partitions.

Another common fault in plan is to have one of the rooms of such dimensions that it is impossible to light it advantageously. Such very large rooms form an essential part of many high schools, even of modern construction; they are used as rooms of assembly, and also as the general study rooms, each pupil having a desk there, and only leaving it as occasion offers to go to small recitation-rooms. Such rooms are usually lighted from the right and left sides. The width between the windows is sometimes as great as seventy feet. The great distance of the windows from the central parts of the room is a marked disadvantage. Twenty or twenty-five feet is as far as a desk ought to be from the window.

Associated with this fault,—or independently,—may be found a deficiency in the size of recitation-rooms. It seems to be supposed that these places do not require as much space as ordinary class-rooms, the fact being, that they are apt to be in use about all the time, and therefore are in no way to be excepted from strict requirements. When looking for instances of bad ventilation and overcrowding, one should not omit to visit these rooms. The allowance of cubic space for each scholar will be mentioned later.

A type still in vogue, which has some decided merits, may be called the four-square plan. It contains, on each floor, four rooms and a corridor; the corridor runs from front to rear, and the rooms are in pairs to right and left. There is a staircase in front and rear. Each room is lighted from one side and the rear of the scholars: each room is a corner room. The type which is likely to supersede this one is based on the wish to give more light and ventilation in the corridors. Both are illustrated (Figs. 4 and 5). It would be rash, however, to point to any one plan as likely to have exclusive success.

Fig. 4.

The objection to spiral stairs is, that the tread is very narrow on the side next the wall, and a careless person easily gets a severe fall. The tread should never be wedge-shaped. It is a good plan to break up a flight of stairs by placing a landing half-way, with a full turn. Both stairs and corridors must be well lighted. The steps must be easy to ascend.

It is desirable to build stairways as nearly fire-proof as possible. They may be enclosed in brick walls, so that fire from the main edifice will reach them with difficulty. One staircase should be placed at each end of the building, so that no room need be cut off by smoke or flame at the

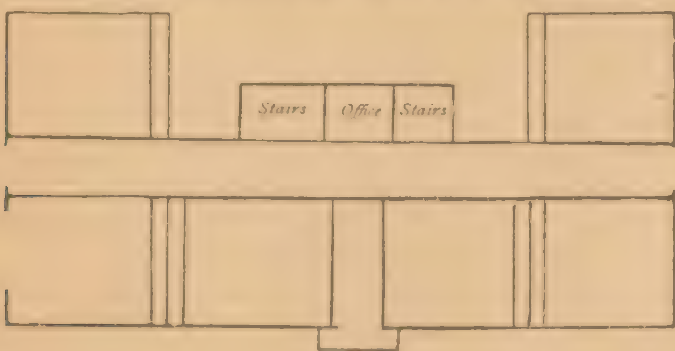


Fig. 5.

outbreak of fire: it will be easy to go a step further, and place them outside, or partly outside, of the building, for more complete isolation. If the framework is of iron, the treads may be of hard wood, which makes them for all practical puposes fire-proof.

These precautions are among the first to be taken against fire—we might say against panic, for the danger to life from fire, in a school where children are orderly, is scarcely to be thought of. A thousand children can be got out of a large school within two minutes of an alarm

from the principal. They say it can be done in less time; it depends, however, on having the children exercised in a special "fire-drill," the sole object of which is to pass them out as quickly as possible. In the best schools this drill is given *without warning* once a month.

Further precautions against fire may be taken: they ought not to be limited, however, to prevention of combustion, but should include some means for carrying off smoke, which is so apt to cause panic. To this end, it is proposed, by the chief engineer of one of our large cities, to have a large valve, easily opened, at the roof, so as to draw out great quantities of air or smoke. There may be also extra flues, built in the partition walls, communicating with such floor spaces or wainscot spaces as may be supposed likely to be the seat of fire. The flues will not afford a supply of air to the flame, but will only carry off the smoke and gases instead of letting them come through the floors. The writer does not express an opinion upon these suggestions, but they rest on good authority. Fire-proofing beneath the floors with layers of plaster is certainly to be recommended; also, the practice of bringing the floors close up to the walls, thus cutting off the connection between story and story, which is so often the means of transmitting a fire with surprising rapidity to the upper stories. Perhaps the chief benefit of all these precautions, as regards safety of person, lies in the feeling of security against sudden conflagration, which will give confidence in the moment of alarm to some teachers who might otherwise be overpowered by sudden dread.

There are some buildings in most cities which were never meant for schools, but which are crowded with poor children, whose danger would be imminent in case of fire. A so-called fire-escape, placed on one of these wooden traps, affords a possible means of safety, but, for the most part, a good staircase in a well built school-house is the best "fire-escape."

The passages to be passed through by the scholars in reaching the door should be wide; the outer doors should swing towards the street. There should be two doors at least,—one for each staircase.

The competition for prizes for model school-house plans, which took place in 1880 in New York, has already been mentioned. The conditions upon which the committee of award based their judgment deserve to be quoted. In their opinion "a public school building to be erected in a large and densely populated city, should possess the following qualifications, viz.,—

"I. At least two adjoining sides of the building should be freely exposed to light and air, for which purpose they should not be less than sixty feet distant from any opposite building.

"II. Not more than three of the floors should be occupied for class-rooms.

"III. In each class-room not less than fifteen square feet of floor area should be allotted to each pupil.

"IV. In each class-room the window space should not be less than one fourth of the floor space, and the distance of the desk most remote from the window should not be more than one and one half times the height of the top of the window from the floor.

"V. The height of a class-room should never exceed fourteen feet.

"VI. The provisions for ventilation should be such as to provide for each person in a class-room not less than thirty cubic feet of fresh air per minute, which amount must be introduced and thoroughly distributed without creating unpleasant draughts, or causing any two parts of the room to differ in temperature more than 2° F., or the maximum temperature to exceed 70° F. This means that for a class-room to contain fifty-six pupils, twenty-eight cubic feet of air per second should be continuously furnished, distributed, and removed during school hours.

"The velocity of the incoming air should not exceed two feet per second at any point where it is liable to strike on the person.

"VII. The heating of the fresh air should be effected either by hot water or by low pressure steam.

"VIII. The fresh air should be introduced near the windows; the foul air should be removed by flues in the opposite wall.

"IX. Water-closet accommodations for the pupils should be provided on each floor.

"X. The building should not occupy more than half the lot."

The only comments by way of exception that need to be made upon this are, that in VI it seems hardly possible to expect a temperature varying only two degrees all over a room, if the difference between ceiling and floor is intended to be included; and further, that the method of introducing fresh warm air, etc., given in VIII, is not the only desirable one, as will be shown under "Ventilation" later in this essay. In No. IV the size demanded for windows is based on the requirements of city architecture.

In other respects the recommendations deserve unqualified approval, as embodying the chief sanitary requirements in a city school-house.

Height of School Buildings. Not merely on account of danger from fire, but for reasons affecting the health of pupils, excessive height has been, within a few years past, much spoken against. It seems desirable, on the whole, to limit the height to three stories, of which the first two should contain most of the school-rooms. The reasons for this restriction are such as apply chiefly to girls of the age of fourteen and upwards; more especially, to young ladies in normal schools and seminaries. Not to enlarge upon this point here, it is well to notice the unwillingness of such girls, if placed in the upper story, to descend to the play-room or yard for recess. The climbing of many flights is an evil which may come about in another way, viz., when scholars study in one story and descend to another for each recitation. In such cases the need of consulting teachers before building is evident. The plan of the house should be made to depend on the plan of study, and architects can seldom fail to gather some useful information from those conversant with the uses to which their work is to be put.

A point to note in conclusion is the smallness of the yards allotted for the children's play in American cities as compared with what is found in Europe.

III. VENTILATION AND HEATING.

This is one of the chief topics, and one of the most difficult, connected with School Hygiene.

It is comparatively easy to build a convenient and spacious house: the requirements are well known, the cost is tolerably definite, for a given place and time. The problem of merely heating a given space is also one of moderate difficulty. But ventilation is a matter about which a general opinion is hardly yet formed, and the cost of which is very vaguely known. People in general are not yet agreed as to what constitutes good ventilation—how much fresh air per hour is required.

Between a barely tolerable system, eked out by opening windows, and a system which really furnishes a supply of from thirty to sixty cubic feet of fresh warm air per head and minute, there are many shades of difference. Few have a mastery of the somewhat complicated questions involved; very few have seen successful and logical experiments made; and many are called on to act as judges—to act upon an opinion which they cannot have formed.

Amount of Fresh Air and Cubic Space Required. It is unfortunate that authorities differ so widely on these points. The New York Metropolitan School Board sets the minimum allowance of space per head at from 70 to 100 cubic feet, according to age. Fortunately, this does not represent the general practice in that city,—though, to the eye, the appearance of many infant classes suggests the idea of sardines in a box. Most authorities would wish to double these figures, at least.

According to recent inquiries in Boston, there is no corresponding law or regulation; but it is customary to build rooms for fifty-six pupils, with an allowance usually ranging from 160 to 220 cubic feet per head. Prof. Kedzie, of Michigan, claims 300 cubic feet; A. C. Martin, 220; various German states, from 120 to 284. The Conseil Supérieur d'Hygiène Publique, in a recent report to the Belgian Ministry of the Interior, recommends a minimum of 6¾ cubic metres per head, or about 240 cubic feet, a space which requires the unusual height of 4½ metres, or about 14 ft. 10 in. The high position of the sanitary service, especially as regards schools, in Belgium, lends weight to their recommendation.

It is the writer's belief that it is desirable to limit the size of classes to forty (40) pupils. Experts in education recognize the gain that accrues to the individual scholar from such limitation. If we base the calculation on this figure, we have more liberty of choice between large and small rooms in making our plan for a building. The advantage of space is twofold;—it enables us to introduce large volumes of air, fresh and warm, without danger of draughts; and it gives more value to the practice of airing-out the room by windows at recess times, since a large roomful of fresh air lasts longer than a small one. But there is such a thing as too much space, entailing difficulties in regard to discipline and teaching, and making it hard to secure good light. For example, a class of fifty-six, with an allowance of 250 cubic feet each, requires a room of

the capacity of 14,000 cubic feet, or 27 feet wide, 37 long, and 14 high, dimensions which can hardly be profitably exceeded, if indeed they are not too great already.

As regards the amount of fresh air to be introduced hourly, it is desirable to found our ideal upon the basis of Parkes & DeChaumont's views, which represent the best authority. By depending upon the testimony of their senses as to whether rooms were "close" or "fresh," these authorities reached the conclusion that it is not desirable to allow the amount of carbonic acid in air to exceed the proportion of 6 parts in 10,000. Any higher proportion seemed to be attended with perceptible closeness.

Now, assume that fresh air from out of doors contains 3½ parts in 10,000, which is a trifle below the usual rate. A room of the capacity of 10,000 cubic feet, freshly filled with this air, and tenanted by one man, would receive from his lungs an addition of 2½ cubic feet of carbonic acid in 4½ hours, raising the total to 6 cubic feet. If, then, 10,000 cubic feet will last 4½ hours, the supply for one hour should be 2,400 cubic feet, or for one minute, 40 cubic feet.

The usual assumption is, that "fresh" air contains 4 parts, not 3½, in 10,000. If so, the hourly requirement is about 3,000 cubic feet, or 50 per minute. Billings increases this to 60. If an average school-room of the better class contains an allowance per scholar of 200 cubic feet of space, there would be a necessity for renewing the air completely every four minutes, or fifteen times in an hour. This requirement, however, is intended to apply to rooms used day and night, such as barracks. For school-rooms, the amount may be less, owing to the opportunities for frequent airing, and the total disuse out of school hours. The writer agrees with Dr. Billings in the belief that, *for schools*, the allowance of *from 25 to 30 cubic feet per minute and head* will answer all needful purposes, if supplemented by occasional airing-out during and after school.

It is evident that if air is to be introduced so rapidly, there should be a liberal allowance of room, in order that the incoming air may not be felt as a draught. The outgoing air, by the way, is rarely felt; but a very vigorous draught may be appreciable two feet from the register.

Do children require a smaller allowance than adults? or, Do small children require less than large ones?

One answer, in the affirmative, is derived from the estimates of the amount of CO_2 exhaled at different ages. Breiting gives it, for girls aged seven or eight years, at a little over 10 litres per hour; at the age of eight or nine, 12 litres. If engaged in singing, it is 16.7 for the latter age. Boys aged twelve or thirteen expire 13 litres; during singing the amount rises to 17. Scharling gives, for the age of ten years, close upon 10 litres; for a boy of sixteen, 17.4; for a young woman of seventeen, 12.9; for adults, a little more. Pettenkofer & Voit give 16.8 for a weak man, and 22.6 for a strong man.

It would appear, then, that there is a decided difference to be allowed

for. Primary pupils expire less CO_2 than high school pupils, in the ratio of 2 to 3; or perhaps the difference is still greater. If a room ought to contain the cubic space of 250 feet per head for larger scholars, it need contain only 180 for the same number of small scholars. In other words, forty large and sixty small scholars can be accommodated in an equal space.

This estimate, however, is admissible only on the supposition that the ventilation is efficient. In case of defect, or apprehended defect (and this covers a wide ground), the young children should have equal room with the older ones, on the ground of their comparative inability to cope with the deleterious effects of bad air; also, because in contracted quarters the danger of draughts from windows is greater. It has been said that children need a proportionately large allowance, "because metamorphosis of tissue goes on more rapidly in them." We have two means of estimating the amount of tissue-change,—the quantity of CO_2 exhaled, and the quantity of *food consumed*. On the whole, the latter item is sufficient for the argument, and may be believed to represent the amount of change of tissue very well. It is quite evident that, though boys of fifteen may consume as much food as men, children of eight do not. A supply of air, then, which would be liberal for a large boy, would be more than liberal for a small child. The degree of allowance to be made is a point upon which distinguished authorities differ. DeChaumont would place three times as many children of four or five years in a given room as youths of fifteen or sixteen, while Billings would allow very nearly the same amount for children of all ages.

Dimensions of Ventilating Apparatus. Let us suppose the case of a school-house to be planned for thorough ventilation. It is assumed that all the air to be extracted is to be carried by flues through the roof. We will first consider the flues for extraction. The resistance offered by friction is of great importance, and should lead us to make the flues of liberal size, as straight as possible, and smooth internally. A flue of less than eight inches internal diameter is not worth much. The inside should be finished in smooth plaster, or, better, with sheet metal; never with rough brick unless very large. Angles check momentum very greatly; so do horizontal passages.

Suppose a single room to be ventilated by a single brick flue, straight and well made; and suppose the only force to produce a current is the warmth of the air leaving the room at 68°. It is probable that if the flue is of moderate height, with no fire, the upward draught will seldom exceed the rate of two feet per second. An average of two would be a liberal allowance. If there are fifty-six pupils, the chimney is expected to discharge 28 cubic feet per second, and in order to do this, it must be at least 14 feet in sectional area, or about 4 by 3½ feet inside measure. The register opening to this flue should be at least as large. (The reader may try to form an idea of this by measuring the dimensions on the wall.)

Not to speak of the register, such large flues cannot be introduced into

a building already finished, and can hardly be thought of in a new plan. There is, indeed, no necessity of so large a shaft if we provide a somewhat different arrangement. If convenient, we can cause the furnace-smoke to be carried up this flue in a cast-iron pipe, thus increasing the heat, and possibly doubling the velocity. In large buildings, moreover, the whole system must be centralized, and this is done in two ways,—first, by conducting the foul air from each room by long tubes to a central heated chimney; and second, by grouping rooms so that they discharge their foul air at once into the chimney, without intervening "ducts." The latter is the plan of the Bridgeport, Conn., high school, to be described presently.

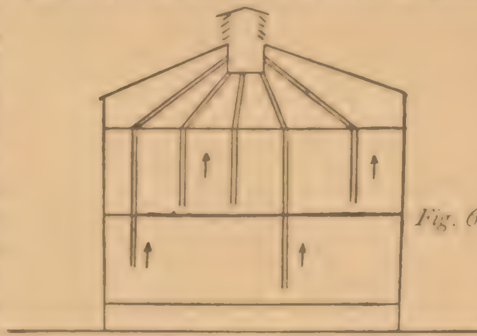


Fig. 6.

Fig. 7.

Three illustrations (Figs. 6, 7, and 8) show how the first plan may be carried out. It is to be observed that they all imply the expenditure of extra heat to force a draught; also that in No. 6 the heat is applied in a chamber in the attic (which may be of wood lined with sheet metal), while in the others it is imparted by the smoke-flue of the furnace. The most economical plan of the three is stated by Planat to be the last; the least economical, the first. The Bridgeport school plan is illustrated in the next plan (Fig. 9). It is ventilated by two large, brick shafts, which curve and meet in one at the attic story. In their upward course they pass directly by each school-room, and take foul air by one large opening from each. These same shafts also carry the tin flues for the hot air supply of the rooms, one such flue for each room. The heat lost from the tins goes to keep up the heat of the shaft, and increase the "suction" power. The smoke-flue is utilized in the same way, and there is a "suction coil" for extra heat in the upper part of the flue.

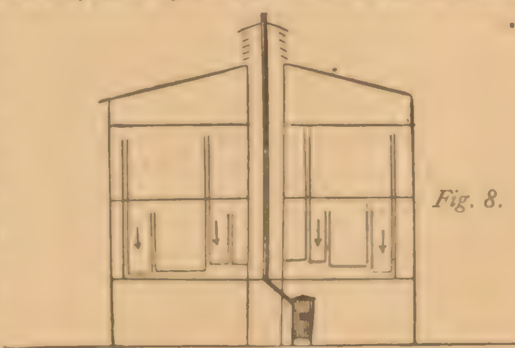
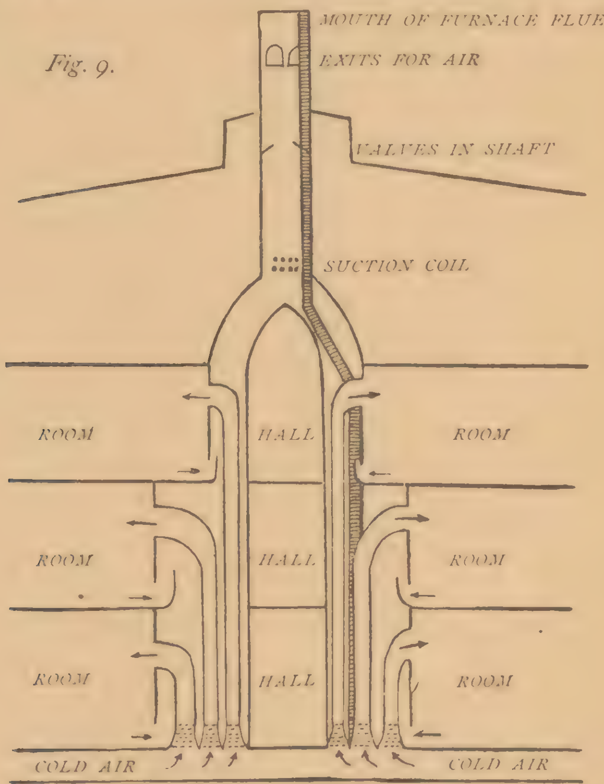


Fig. 8.

With but one inlet and one outlet, there was need for special care in planning the position of the registers. The plan adopted seems to be quite successful in distributing the air and equalizing the temperature. The inlet for hot fresh air is near the ceiling: the current travels towards the windows: a descending current near the windows, originating in the cooling effect of the glass, continues the movement, and finally there is a strong outward movement of air at the inner corner of the room on the level of the floor. Something like a circular movement is thus produced. In the diagram (Fig. 10) arrows are introduced at points where currents are felt, and the intervening points may be filled in by the reader's judgment. The figure represents the room in section, with temperature taken

Fig. 9.



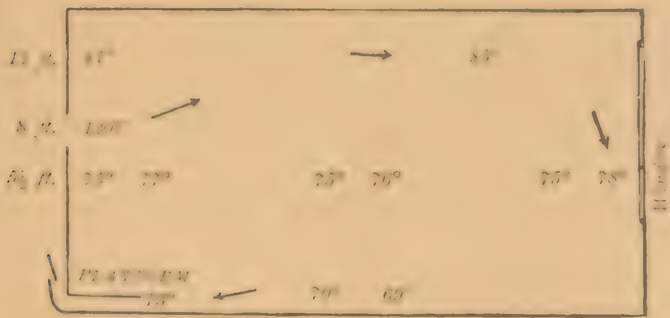
BRIDGEPORT, CONN., HIGH SCHOOL.
Vertical Section.

simultaneously after the apparatus had been in operation forty-five minutes. Similar arrangements have been since made, to the knowledge of the writer, in schools in Auburn, New York, and Newton, Mass., with good success.

The orifice for the exit of foul air ought to be a good deal larger than that for the inlet of fresh air. In examining Fig. 9, the reader is desired to make the correction mentally.

The use of steam power as a ventilating agent is not a novelty in other public buildings, but in school-houses it has been tried, so far as known to the writer, only in Boston, and that within a few weeks past. The experiment is one which it is very desirable to make, by way of testing its economical value. The arrangement consists of a fan placed in the space below the ridge-pole, within a box, propelling the air upwards through the cupola, and exhausting by good-sized flues from below. The motor is a high-pressure engine in the cellar, which seems to require

Fig. 10.



BRIDGEPORT HIGH SCHOOL

Vertical Section of a Room, showing Temperatures at a height of 1 inch, 5½ feet, 8 feet, 12 feet from floor.

from twelve to fifteen tons of coal during the winter, and the constant presence of an engineer. A new form of engine ("vacuum engine") is proposed, requiring no separate fire, and run by jets of steam from the boiler which heats the school, at an extremely low pressure. No tests for carbonic acid have been made, but the anemometer test, applied in two schools, gave a rate of discharge equivalent to twenty-four cubic feet per head and minute, which is about as much as we can ask for. The expense of introducing the appliances is stated as moderate; flues, not to be considered, being required in any case; vacuum engine (no boiler required), about $500; and fan, something more, besides cost of gearing to transfer power from cellar to attic. In one school a certain amount of rumbling noise is heard (but not complained of), due to vibrating motion in the attic, the apparatus having been introduced not as part of the original plan, but after the school was built. In the other building scarcely any sound was heard.

The arrangement of flues for such a plan has nothing peculiar. It requires chiefly the avoidance of angles, or rough and narrow flues, and is represented in figure 6, the fan being placed at ****, just below where the cupola is set upon the roof.

No system for exhausting air by hot flues or by steam power should be introduced without providing for the introduction of a corresponding amount of fresh-warmed air. Hence it follows that ventilation and heat-

ing constitute parts of one general problem, and that the same mind should plan both.

"Indirect" heating is the only kind worthy of our consideration. In cases where stoves are set in school-rooms, they should be made indirect heaters by the use of screens, as is hereafter described. For larger buildings, steam heat, by means of coils arranged in boxes in the basement, is probably the best. Auxiliary coils may be placed in entries, but not, as a rule, in school-rooms. Ventilation cannot be had without some increase in the bills for fuel. There is reason, however, to think that the amount of increase is not so great as might appear. In our worst ventilated schools there is a good deal of warmed air let out at windows, in an unsystematic way.

Good ventilation implies that cold draughts from open windows are done away with: hence a lower degree of heat in the room is sufficient for comfort. It also implies a rapid change of air, with equalization of temperature, so that the feet are kept warm: this also enables us to be comfortable at a low temperature. A third point, bearing in the same direction, is the greater activity of the circulation and of the change of bodily tissue, and the consequent increase of bodily warmth in fresh air.

The writer has at least twice found opinions strongly expressed in favor of the results of ventilation. Once in a new primary school at Springfield, Mass., where the teachers agreed that they could get along with the thermometer some degrees lower in their new, well ventilated quarters, than formerly was the case in close rooms. The other instance points indirectly in the same way. In the new building of the Massachusetts Institute of Technology, with nearly perfect ventilation, the quality of the work performed is said to be decidedly superior to that which was done in the old building, which has no system worth naming. The ventilation in the new Institute building is very successful. It is effected by a fan in the basement, which forces air through openings in the inner walls of the rooms at a high point, the air escaping by flues in outer walls at low levels. The allowance per hour and head is 1,500 cubic feet in lecture-rooms, and from 2,000 to 4,500 in laboratories of various kinds. The analyses of air gave from 4.87 to 5.23 parts CO_2 in 10,000, in a room which was half full of students. The estimate for a full room would be from 7 to 8 parts per 1,000. Corresponding analyses in the old building gave from 9 to 12.34 in a room with doors and windows open, half full; if filled it would probably stand at 21 or 22 in 10,000. Prof. Woodbridge's estimate of the fuel burned last winter is 307 tons for the old and 404 for the new building, and some allowance is to be made for the fact that all the boilers are situated in the cellar of the older building. Both are of nearly the same size, and are equally used, and for the same purposes.

However encouraging these results, it is seen that perfection is not yet reached. By way of comparison, a few selected data are given, showing the number of parts in 10,000 of CO_2 in the air of various localities. (See table.)

It is probable that the bad air of German schools is one cause of the prevalence of near sight and other defects of vision.

The standard of 6 per 10,000 is not likely to be reached in schools at present. Perhaps we shall have to admit the practical justice of Prof. W. R. Nichols's remark, that 10 in 10,000 is as low as we can expect to find in schools with fair ventilation.

AMERICAN SCHOOLS.

		No. of rooms examined.	Parts CO_2 in 10,000.	Observer.
Philadelphia	1875	9	12.2	E. Thompson.
Boston	[illegible]	40	14.5	A. H. Pearson.
Boston	1875	111	11.9	Draper & Nichols.
Boston	[illegible]	39	15.6	W. R. Nichols.
Michigan		46	22.9	R. C. Kedzie.
New York city	[illegible]	17	20.8	H. Endemann.
Lynn, Mass	[illegible]	8	17.5	Prof. Hills.

GERMAN SCHOOLS.

Annaberg, 5 schools	39.9	O. Krause.
Wilhelm's Gymnasium in March	55.8	Oertel.
" " in July	22.9	"
Celle, Gymnasium, various rooms	20.50	Baring.
Celle, Volks-schulen, most rooms	90	"
" " one room	120	"

Much has been said regarding the proper position for outlets and inlets for air. One false view may be corrected at once,—the notion that carbonic acid gas is the agent that is chiefly noxious, and that this gas seeks the lower levels. It is not specially dangerous in quantities found in schools—the animal vapors from skin and lungs are more so—but it represents the degree of organic pollution fairly well. It is not found chiefly at a low level. If there is any difference, the upper levels are sometimes more impregnated, owing to the breath rising in a cool room; but the difference is small, and, in a room with rapid ventilation, not distinctly traceable. The air from the pupils' lungs may be assumed to be distributed through the apartment rather quickly. The process of ventilation then becomes, not a removal of the exhaled air, but a dilution by the introduction of large quantities of fresh air.

A test for carbonic acid is not easily made in a way to satisfy scientific demands, but an approximate test can be made in a minute by an unskilled person. An ounce of fresh lime-water in a ten-ounce bottle of the air to be tested, shaken vigorously for half a minute, will indicate a fair degree of purity, if it is not distinctly made turbid. One should have a little practice, even at this simple operation.

The writer has endeavored to make a convenient and portable apparatus which will give an indication of the number of parts in 10,000, within a range of error not exceeding one part. To some extent the instrument is successful. It is based on Lange's method. A series of bottles of known size was chosen, graded from large to small, and fitted in a wooden frame. The whole apparatus is carried to the room to be tested. The bottles have been previously filled with water, and when inverted the air fills them at once. They are stoppered, and carried to the laboratory, where a given amount (say one half ounce) of lime-water (chosen as being less liable to change than baryta-water) is introduced into each, and also a few drops of a solution of phenolphthalein, which gives a rose color to the lime-water. By shaking for a good many minutes the carbonic acid is made to neutralize the lime; the approach of complete neutralization is marked by the fading of the rose color; and when satisfied that the process has gone on long enough, we select the largest bottle that shows the complete change, and say,—

The air in this bottle measures (say) 10 ounces; it contains enough CO_2 to neutralize (say) $\frac{1}{2}$ ounce of lime-water: how much CO_2 is here? and how many parts in 10,000 parts of air does it stand for?

The calculation is of course made previously for each bottle, so as to reduce the labor of a test to the mechanical operation. The act of shaking is fatiguing, and the charging of the bottles requires some practice, and a well graduated tube. No figures are here given, but by a comparison with simultaneous analyses made by Pettenkofer's method, an encouraging degree of accuracy has been observed. The point of difficulty in this and similar processes is to determine when the carbonic acid is to be considered as having been fully taken up by the lime. This fault seems to attach to Mr. Owen's ingenious process, given in Billings's "Ventilation and Heating."

Source of Supply of Air. The purity of the source must be carefully guarded. A wooden duct is the usual means of conveying the air across the cellar to the furnace. Such ducts easily open at the joints, and let in cellar air: hence painting from time to time may be useful, unless tin be substituted, or galvanized iron. The interior should be accessible in some way for cleaning, as dust cannot but accumulate with time. The inlet, out of doors, is to be guarded with a wire screen, and is so situated as to be out of the way of mischievous persons. Bad smells are sometimes noticed in a school, which enter through this channel. It is hard to tell, in certain neighborhoods, just where to place the opening. The ground is damp; the air at ten feet is odorous for various reasons; and at thirty feet the smoke of neighboring chimneys is blown into the inlet;—it is

usual, however, to make the cautionary remark that malaria and dampness linger near the ground, and, as a rule, ten feet from the ground is a good place.

Scrupulous cleanliness of the cellar is necessary. If there are water-closets there, they had better not be near the ducts, nor even in the same division of the cellar, since the ducts are provided with doors which are liable to be left open contrary to orders. The misuse of such valve-doors is one of the crying sins of janitors. Many a master has a perpetual warfare with this functionary on account of this. The janitor's object, first and last, is the saving of coal in order that he may receive credit for economy, and his habit is to close the outer valve, opening the one that leads from the cellar, thus feeding his furnace or coils with cellar air at 60° instead of the cold air out of doors. In this way the writer has found a school-house filled with air which must have passed through the furnace two or three times, being drawn down through the entries to the cellar, and then sent back through the furnace. Excessive heating of the air is not so frequent a fault at present as formerly. A report made to the Boston school board in 1846 complains that the air sent to school-rooms is frequently heated to 500° or 600°. This may be simple exaggeration, but there is no doubt that a heat approaching 200° is not uncommon at present. Circumstances alter the requirements greatly, but for schools by daylight, the range should not much exceed 120° F., nor fall much below 80°. In order to fulfil this demand furnaces and boilers should be made very large. Steam heating is one of the best methods. The pressure upon a boiler of proper capacity need never exceed ten—perhaps it should not exceed five—pounds to the square inch, and it should frequently run down to one pound. The danger of explosion need hardly enter into the calculation if there is good management.

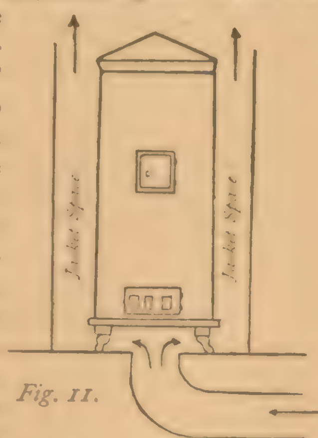


Fig. 11.

Ventilating-Stoves. A useful apparatus for aiding ventilation is furnished by a class of stoves which are provided with an inlet for fresh air, and a chamber for warming it before it is introduced to the room.

Figure 11 shows a stove having a jacket of sheet metal, a space between the jacket and stove, and a fresh-air flue, with a valve operated from the room. The principle, as regards air-supply, is not essentially different from that of the "Fire on the Hearth," the "Jackson Ventilating Grate," and Galton's ventilating fire-places. The method is practically valuable, though the stoves I have seen do not really supply enough air; that is, a stove large enough

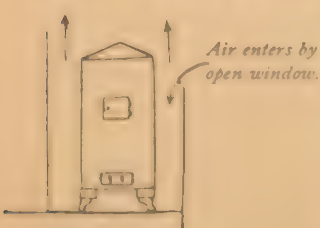


Fig. 12.

to *heat* a given room does not introduce nearly enough air to *ventilate* it. The column of hot air is very short, and the velocity moderate. Yet, where stoves are to be used, there is an obvious gain in using this kind. It ought to be supplemented by a powerful chimney-draught, the chimney being made of liberal size, and heated by the passage of the stove-pipe: an opening for ventilation is to be made near the floor. In still other ways ventilation may be aided by the stove-pipe, as will be seen from Figs. 13 and 14.

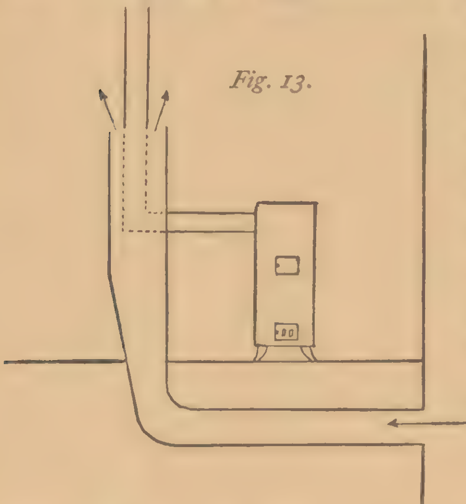


Fig. 13.

Figure 12 shows a screen (supposed to form a semicircle) placed by a stove near a window, which is opened.

Figure 13 is like Fig. 11 in principle.

Figure 14 shows how a lower story may be ventilated.

The last four illustrations are from Billings's "Ventilation and Heating."

The evaporation of water in connection with heaters is probably useful, but the writer is not inclined to consider the matter one of primary importance. It is successfully dispensed with in some of the best ventilated new wards in hospitals.

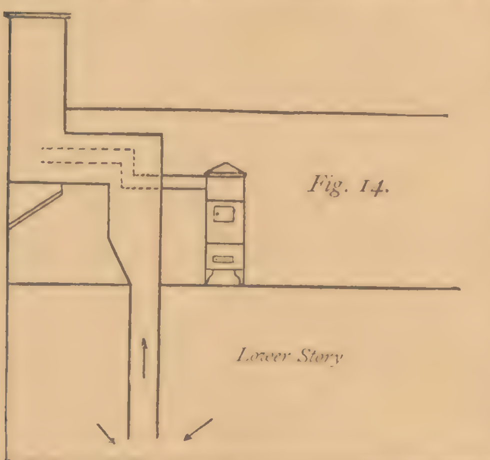


Fig. 14.

Children often come in with cold and damp feet. It is desirable to provide some kind of foot-warmer in the hall or basement. A good one is made of an iron plate, 2½ or 3 inches thick, set on a flat steam-coil.

Opening Windows. This may be regarded in two lights, according as the scholars are *at work*, or *moving and exercising*. To keep windows partly open seems an absolute necessity in many school-rooms. In one-roomed country schools, one of the first steps in sanitation is to insist on the upper sashes being arranged so as to be lowered. An open window is an evil, nevertheless, in cold weather. The palliative measure to be recommended is a strip of board a few inches wide placed so as to deflect the current from under the lower sash, and make it pass above the heads of pupils. This is a decided

mitigation of the draught. It is very often liked in rooms where the ventilation is otherwise bad. A tilting sash at the top of a window cannot safely be used in winter. Such a sash, however, ought to be placed over every room door to enable the occupants to share to some extent in the purer air of the entries. There is no question of the good done by temporary opening of windows and doors for a minute or two while scholars are exercising. The effect may be supposed to disappear in two minutes or so; but when combined with a short physical exercise in the standing posture, its effect, both moral and physical, is undeniably good. In a very carefully conducted school known to the writer, this is done every hour, the period of five minutes being allotted for that purpose, unless there is a regular recess. At recess time, also, it is the rule that no child shall remain in the rooms, but that all shall go to the play-rooms under charge of their teachers, the windows in the mean time being opened by scholars deputed for the task. These measures, well carried out, greatly relieve the condition of a school which has no efficient system of flue ventilation.

The "Eureka" ventilator is an opening in the wall to let in air directly. It has a valve, and the passage is bent so as to throw the air upwards. It is a useful accessory in some cases where a thorough ventilation is not planned for. Similar openings are often found behind steam-coils in school-rooms. Their utility is delusive:—they deliver a very small quantity of air, and are liable to be stopped up by accident, or for the purpose of keeping out the cold.

Much has been said of the supposed capacity of cast-iron stoves to let carbonic oxide gas pass out through their pores, thus contaminating the air with a peculiarly deadly poison. The present weight of evidence does not sustain this belief.

IV. SEWERAGE.

It is difficult to trace any large amount of disease in schools directly to offensive privies or sewers. There can be, however, do doubt that some is so caused. The school is often supplied with water from a contaminated well. Bad air and stenches are not always provocative of illness, but the common-sense of civilized races suspects them, and there is no doubt that they may promote debility, headache, loss of appetite and digestive tone, and general depression of vitality; while in the minds of some physicians there is no doubt that dysentery may be caused, and perhaps typhoid fever, and that scarlatina and diphtheria may be aggravated by exposure to foul air. Pneumonia, tonsillitis, rheumatism, and neuralgia are probably to be included.

Although drainage, as applied to school buildings, is governed by the general rules applicable elsewhere, it may yet be desirable to note, in passing, the chief of these rules. A certain number of points of more special application will be noticed afterwards.

In all houses, whether used for school purposes or not, the drain, soil, and waste pipes ought to be of iron, visible and accessible throughout

their course, if possible; without angles, as straight as possible, and never horizontal. Soil and waste pipes are to be carried up full size, two feet above the house roof, and there guarded against the weather. A trap is to be provided for each sink, basin, urinal, or closet, and a running trap for the outlet of the drain, with an opening from the drain for ventilation, just inside the trap. Safes are to be connected with the drain directly. Rain-water leaders are not to be used for any other purpose, and *vice versa*. The best trap for sinks is, perhaps, the ball trap. Ordinary S traps are often shallow, and are rather more easily siphoned than D traps. Traps are to be ventilated by 1½-inch pipe leading to the general ventilator (*i. e.*, the continuation of the soil or waste pipe) above all other inlets. If not ventilated, the omission must be made upon good authority. Bell traps are convenient for the floors of urinals, but they are rather inefficient unless the seal is made deeper than usual.

In many towns there is a supply of aqueduct water, but no public sewer. In this case the drain usually discharges into a cesspool, loosely built, which permits the escape of fluids into the soil. This arrangement is satisfactory when there is a good deal of spare land, and when the soil is light and gravelly. In a clayey soil it may be entirely inadmissible. If the population is even moderately compact, sewers should be provided at once, under peril of infecting the subsoil air to such an extent as to influence the air of cellars. City schools are usually provided with water-closets proper, or with flush-tanks or iron latrines. In country schools the ordinary privy is almost universal. Good water-closets are doubtless the best arrangement, so long as they are kept in order. No kind yet invented is free from the danger of derangement. A hopper which gives a full and quick discharge of water is probably the best for schools. The discharge may be dependent on the movement of the door or seat, or may be arranged to occur at once in all the bowls at a given signal.

The flush-tank is a long vault of masonry, over which the seats are built. It should have a round bottom and rounded corners. At one end is a tap of water; at the other, in the bottom, a plug to let out the contents. The janitor should remove the plug, and flush and swab the interior at least once a day. With proper ventilation there need be no offensive odors. If placed in a well lighted cellar, it will give satisfaction as long as it is carefully attended to; but such is human nature, that we may expect to find a certain proportion of cases in which due care is not given, and consequently dissatisfaction is felt. There is a great difference of opinion among intelligent heads of schools upon this point, some being unwilling to tolerate these arrangements under the house-roof, while others are strong in support of them. On the whole, it seems better, if we cannot be sure of the future character of the service rendered, to place all of them out of doors. A flush-tank will not freeze in the climate of New York city if emptied at night. In colder places it may be necessary to empty not only the tank (which in any case should be always done), but also the pipes leading to it, directly after school.

An unobjectionable apparatus consists of an iron sink coated inside with a firm glaze, rising to contact with the seats, and only deep enough to hold a few inches of water, with a suitable space above. There should be no riser. The whole should be above ground, in a place moderately warmed; the water to be drawn off daily, and in cold weather not replaced till the next day. For an out-of-doors sink, if iron is used it must not be supplemented by a wall of masonry built above it, as the contraction and expansion of the metal cause a breaking away from the masonry.

As regards freezing, the writer is informed by the superintendent of schools at Springfield, Mass., that it does not occur when the water is shut off from the out-door sinks and drawn off.

A school-house should have one water-closet in-doors, for the use of females. A building of two or more stories may properly have one on each story, in order to save girls the fatigue of climbing stairs in cases where the privilege is desired, and also for the teachers' use.

The urinal appears to present a difficult problem; but the whole matter lies in two words—non-absorbent surfaces and frequent cleaning. One of the best forms is composed entirely of slabs of slate, forming a wall five feet high, with a gutter at its foot. The gutter is cut in the floor-pieces on which the pupils stand. Upright slabs divide the space, in the interest of decency. Slate is almost impervious to moisture, and is made quite so by oiling with linseed oil. The apparatus in question is usually furnished with a perforated water-pipe, to keep the front surface of the stone moistened with a sheet of water. The idea is a good one, but requires such exactness of mechanical work that the jets are rarely in perfect order. It has the further disadvantage of seeming to excuse a part of the duty of scrubbing. No portion—side, base, or back—should be neglected in this respect. All these surfaces are liable to grow foul. The amount of work needed to give thorough cleaning is considerable, but it is the only way to secure purity. The janitor's task ought to be lightened by having the whole floor of the apartment slope towards the gutter, so that the hose can be used freely. Some urinals have a raised platform, in order to define the place to stand on. The better way would be to have a depression, which would equally define the position. A monitor, in either case, should stand by to check irregular behavior.

All complication of structure in these departments should be avoided. Concealment of the basin of a water-closet by wood-work is not desirable, and the wooden seat should be so fitted that it can easily be removed for cleaning or renewal. The urinal needs no trough. It should be made of materials which are not porous: no metal work is admissible, for rust is sure to come, and the animal matter of the urine so saturates the rust that it can hardly be soaked out. Paint soon scales off from metal. Wood can be protected by paint for a time, and then becomes soaked with urine unless repainted. The writer has seen marble used,—a material whose absorbent powers may be seen in the large slabs used in restaurants, depots, and such places.

Little need be said about the common privy attached to most country

schools. In many cases this is the last thing attended to. It is practically outside of the teacher's supervision, and one can hardly blame a young and modest woman for failing to see that her duty lies in this direction. It is generally a first-class nuisance as regards odor, insupportable if placed within a convenient distance; but if set off fifty feet or so, the exposure which the pupils undergo in cold or wet weather is a serious matter. In perhaps one half of the cases it is out of repair. The accumulations go on for a year at a time. Finally the walls are covered with dirty scrawls; and very commonly the girls' closet is contiguous to the boys', so that every thing is heard through the partition.

The remedy for a part of these troubles may be found in a more active interest on the part of the school trustee. He can have the place repaired, the scribbling effaced with a plane, and paint applied so as to give a thoroughly neat look. He should try to have both the teacher and the scholars coöperate in maintaining a high standard of neatness, securing, if possible, an occasional visit from the teacher, and making such himself, so as to insure that no breakage or injury goes unnoticed.

Most privies are too dark. Two closets in immediate contact do not insure a proper and modest degree of separation between the sexes: in such a case, the boys and girls should have recess at different times. If there are really two separate out-houses, it is well to have them, and the approaches to them, separated by a sufficient fence. There ought to be plank walks, or raised ways (paved, asphalted, gravelled), to enable the scholars to go dry-shod. But the plan which commends itself to the writer as by all means the best for country schools is the use of dry earth in vaults, emptied weekly, in a shed close to the school-house, and accessible by a short, covered way. It may be thought best to retain the old style of privy for the boys, keeping it at a distance from the house as before; but for girls and little children it is most certainly desirable to have a place which they can reach without danger to health.

Not to mince matters, the direct exposure of a sensitive part of the body to the gusts of a north-east storm is not a thing to be regarded as a trifle; in certain states of the system it may be highly dangerous. And both girls and small children are sometimes led to slight the calls of nature, to their bodily harm, by fear of exposure to bad weather. The plan here suggested is one which may be found illustrated in the report of the Connecticut State Board of Health for 1883.[1] In that report there is given a plan for a country district school, which places both privies under the school roof, but at opposite ends of the structure. Difficulty in keeping the boys' place in order (owing to the need of a urinal) is anticipated, and there is presented, as an alternative, a plan which contains only the girls' closet, as is here recommended.

The figure appended is taken from that report (numbered figure 10—in the present essay, No. 15). It shows a single school-room with separate entrances for the sexes. On the girls' side at the rear is a small, square building, isolated from the main building by an 18-inch passage-

[1] In a paper by the writer of this essay.—SECRETARY.

way around it, but intended to be sheltered by the same roof. The detail of the construction of such a closet is very simple. It requires a receptacle, consisting of a brick trough about two feet wide, rounded at bottom and corners, and coated internally with coal tar to prevent the absorption of fluids or gases. The coating is continued over the top of the bricks and down the front as far as exposed. The bottom is an inverted arch of masonry, bedded in cement and coated with the same, and projecting slightly at the outer end to facilitate removal to buckets. Four feet is a sufficient depth. The bottom ought not to be so low that water from the surrounding land can run into it; and it is better that it should

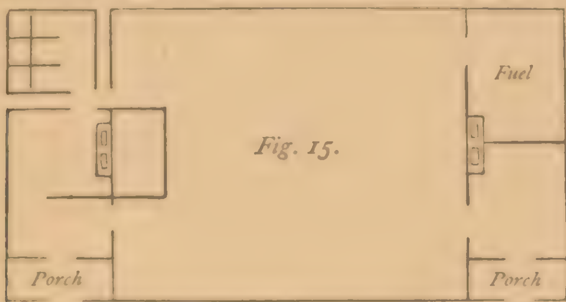


Fig. 15.

be raised above the ground level for convenience in removing the contents. There should be a bin for dry earth in a sheltered place handy for use. Two inches of this earth, finely powdered, are to be spread on the floor of the pit at first, and a little sprinkled on daily: a complete removal is made at the end of each week.

The present writer would corroborate the plan here proposed by cases which he has recently seen, in which the earth removal system is carried out with entire success. An ordinary projection in the rear answers every purpose; the chamber ought, however, to be isolated by a narrow passage-way, furnished with screened windows, which should be kept open. The portable earth-closet may be found useful, but in reality it possesses no advantage over this arrangement.

The only disinfectants required for well arranged water-closets are water, soap, and fresh air. For earth-closets, no more than these and earth are needed. Privies ought not to become offensive: treatment with earth should be resorted to, and if that is thought inapplicable to deep vaults, then let the vaults be shallow for the purpose of speedy removal. But in cases of existing nuisance, or in epidemics of fever, dysentery, or cholera, it is well to be provided with a temporary remedy; and for this purpose, chloride of lime, or corrosive sublimate, as recommended by a committee of the American Public Health Association, may be used. Chloride of lime has the disadvantage of a strong smell. Whichever is used may be prepared by dissolving in soft water chloride of lime (of the best quality) in the proportion of a pound to four gallons, or corrosive sublimate, a pound to twelve gallons. The latter solution is to be colored with permanganate of potash (nine drachms) to prevent mis-

takes. Of the former solution, use a quantity equal to the supposed solid contents of a vault; of the latter, one fourth as much.

If used undissolved, one pound of chloride of lime corresponds to thirty pounds of the solids; one pound of corrosive sublimate to five hundred pounds. Subsequently, chloride of lime may be freely sprinkled over the contents daily. A corrosive sublimate solution may be used for the same purpose, four gallons a day, made by the following formula: Corrosive sublimate and permanganate of potash, of each 2 drachms ($\frac{1}{4}$ ounce), dissolved in a gallon of soft water. This may be kept in a tub or crock, not in a metal vessel. As a precaution in case of an epidemic, wash the interior of the vault daily with this. If green vitriol (sulphate of iron) is used, take a pound and a half to a gallon of water.

V. HYGIENE OF THE EYE.

During the period of school-life, as is now generally known, certain affections of sight increase. It would appear from the uniformity of the results of investigations that the increase is a general rule; and most of those who have treated of the subject have considered it due, in a great degree, to the effect of over-exertion of the eyes in school, more particularly when the light is bad and the rooms unwholesome. It is generally accepted as proved that near-sight is very liable to be inherited. Far-sight (old-sight) is also found in children, and, like near-sight, it increases in frequency and degree as children grow older, until somewhere about the age of fifteen it begins to be less frequent, and at the age of twenty, among students, near-sight decidedly preponderates over far-sight. Dr. E. G. Loring has given diagrams illustrating this fact in the case of three nationalities,—the German, the Russian, and the American. The observers, whose facts are taken for the diagrams, are Conrad, who examined 3,036 eyes of school-children in Königsberg; Erismann, who examined 4,358 eyes of scholars in St. Petersburg; and Derby & Loring, who examined 2,265 eyes in New York schools. The ages in all cases run from the youngest to the oldest pupils, including members of superior schools, up to the age of twenty. In the German table the percentage of near-sighted eyes rises from $11\frac{1}{10}$ in the young children to $62\frac{1}{10}$ in the oldest; in the Russian, from $13\frac{6}{10}$ to $43\frac{3}{10}$ per cent.; and in the American, from $3\frac{1}{2}$ per cent. at six to seven years to $26\frac{78}{100}$ per cent. in the twenty to twenty-first year.

There are a good many other similar series of observations, all agreeing substantially with these, but the German percentages are always very much higher than the American. This is not surprising if school work has anything to do with the result, for German children in all superior schools (real-schulen and gymnasia) are made to do an amount of work which is incredible to our school-boys, and with some results to show in the way of intelligence, too. German children in America also show a decidedly greater percentage of near-sight than American children, owing, no doubt, to hereditary influence. In a board-school in London,

Brudenell Carter has lately found nearly 10 per cent. of near-sight among 207 children. These are the facts, and to most minds they seem to point to a tendency in national life which is truly alarming. It is a distinct drawback to a person's usefulness to have abnormal sight; to have to wear glasses is a serious drawback for many purposes; and yet Germany, which is leading the world in education, is far ahead in respect to near-sight, and we seem to be following her in both points.

There are those, however (as Landolt), who lay the chief stress, as regards causation, upon general conditions of health, maintaining that hardship and poor fare constitute one of the chief causes of near-sight. It may be so, and this is not the place to enter into the argument satisfactorily; but if so, how shall we apply the doctrine to the case of Amherst college, where Derby's strictly accurate statistics show an increase from $41\frac{5}{10}$ to $50\frac{6}{10}$ per cent. during the four years course? In Amherst the conditions of living are as favorable as can be found. Not only is there no "hardship and poor fare," in Landolt's sense, but the young men are under a regime of physical exercise which produces a distinct effect in lessening illness during their residence.

A brief statement of the leading causes, not in any presumed order of frequency, is given here:

1. Inherited tendency.
2. Study while the system is in a weakened condition.
3. Study in a bad light.
4. Study in a bad posture.
5. Study while the eye or brain is fatigued or congested.
6. Study in excess at the formative period of life, when the bodily tissues easily assume a wrong bent.

These will probably cover the ground, so far as relates to our present practical object, pretty nearly. The writer ventures also to offer a series of practical remarks in the form of rules at this point, leaving further discussion till later.

RULES FOR USING THE EYES.

In school work we should require,—

1. A comfortabl_ temperature, and especially let the feet be kept warm and dry.
2. Good ventilation.
3. Clothing at the neck loose. The same as regards the rest of the body.
4. Posture erect;—never read lying down or stooping.
5. Little study before breakfast, or directly after a hearty meal; none at all at twilight or late at night.
6. Great caution about study after recovery from fevers.
7. Light abundant, but not dazzling.
8. Sun not shining on the desk, or on objects in front of the scholar.
9. Light coming from the left hand, or left and rear; under some circumstances from in front.

10. The book held at right angles to the line of sight, or nearly so.
11. Frequent rest by looking up.
12. Distance of book from the eye about fifteen inches.

As regards the causes. No. 2 refers especially to the case of convalescents after measles, scarlet fever, and other weakening fevers. No. 6 requires attention on account of some suggestive remarks made by Dr. Loring in the report referred to. He enlarges on the comparative neglect of out-door life, and the unwholesome habits of eating and living that are found among German children as contrasted with the free play and plenty of fresh air that boys have in our country. He also asserts a belief that since myopia is a disease of childhood, and rarely originates after the age of fifteen or sixteen, it is desirable to give children little severe study until after they have passed that age. More concretely, he points to the life of an English school-boy, with his long hours of foot-ball and cricket, as a better ideal than the German plan.

As regards the rules,—

Nos. 3 and 4 are intended to prevent the occurrence of congestion of the head, which is very likely to injure the eye. A recumbent posture is bad for another reason, viz., because it places the eyeball in unaccustomed positions, disturbing the equilibrium, and deranging the habitual action of the eye muscles.

No. 5. Study before breakfast is usually work done at a disadvantage, since that period is one at which the strength of the system is at a low point in many people. If study is done by artificial light, the trouble is much worse.

No. 7. Some persons are unduly sensitive to light, while others require an amount which is excessive for the average person. Regard may be had to this fact in arranging the pupils. Windows of ground glass, if within the range of sight, are annoying on account of a kind of dazzling effect; if the sun is upon them, they are intolerable.

No. 9. If light comes from the right hand, the pupil's hand in writing shades his work annoyingly. If from the rear, he derives no direct benefit from it unless he turns himself so as to get rid of the shadow; this is the position required in writing by some teachers. A front light, from a window so high that pupils practically are not aware of its presence, is good for the purposes of writing; but such a light can hardly be obtained in a class-room without annoyance. Practically, there must be no windows for scholars to face while employing their eyesight upon tasks. This rule also forbids placing black-boards between windows, so that scholars are obliged to face a full light while trying to read what is written on them. And since the black-board is one of the chief instruments of instruction, and a large extent of it is held desirable, there is an advantage in restricting windows to one side of a room, so that the strip of black-board may run around three sides unbroken, and with every part of it in a good light.

No. 10. The desk lid slopes for the purpose named. It is useful to have light frames for holding books in a more upright position while no

writing is going on. Some desks are made with a joint in the middle of the lid, giving the means of obtaining such an inclined book-holder.

No. 11. The old rule, which punished all who looked up, must be given up. If a pupil is restless and does not apply himself, his case can be reached in various ways, but not by a prohibition of this sort.

No. 12. This distance need not be an invariable one at all times. If generally observed, it will correct the habit of stooping. In teaching penmanship, very great care is needed to prevent the formation of bad habits as regards attitudes. The author has seen a whole roomful of children writing, with their eyes at an average distance of less than three inches from the paper. This exercise must not be engaged in if cloudy weather makes the light poor. Ink should be of a kind that gives a perfectly black mark when first put on paper, not the thin, bluish fluid which is black the next day.

This is the proper place to mention with condemnation the atlases which are often used, crowded with detail in small, delicate letters; also the small, "school" editions of large, standard dictionaries, printed in type which, though clear, is exceedingly fine. Many school-books of our day deserve much praise for their clear, bold type. The use of large-type charts in teaching an entire class is to be commended as avoiding the necessity for a certain amount of poring over books.

Here we may repeat what has already been said about very deep or wide rooms. Many such are wholly unsuited for comfort in writing.

If there is a tendency to near-sightedness, no pains should be spared to prevent a child from getting the habit of holding his eyes too near the book. The distance of fifteen inches is not great; but a child must sit up in order to maintain it. This connects the present topic with the question of school-desks, of which it will be convenient to speak elsewhere. The maintenance of a true posture is dependent on true proportions of desk and seat. When these are obtained, and a child with near-sighted eyes is unable to see clearly at the distance named, it is the opinion of many modern ophthalmologists that he should be furnished with glasses just sufficiently strong for the purpose of desk work. At the same time he may be prevented from crouching down by the use of an apparatus which keeps the head at the distance required. Such an apparatus can be made so as to give no annoyance, and can be kept permanently screwed to the desk. Förster, in 1883, reported several cases of remarkable improvement under this treatment.

Although this is not a place for discussion of the points involved, it may be well to mention that the act of keeping the eyes close to an object is held to involve a muscular effort, both in the act of converging the eyeballs, and also in the (unconscious) act of accommodating the lens by the ciliary muscle, which contributes to the increase of existing near-sight, if it does not originate it. The best light for working purposes comes from above, and is nearly white. This suggests two points:

1. Windows throw light very obliquely on distant objects. It is held by the best authorities that in general they afford sufficient light only

when the distance from the windows does not exceed once and a half times the height of the window itself. This restricts the depth of a room to about twenty feet; a few more may be allowed for the width of an aisle. In one of the handsomest high school buildings in the country the depth from windows to opposite wall is forty feet, which cannot be reconciled with true principles.

2. If light from above is to be sought, the upper part of the window is most valuable, and should be placed within six inches of the ceiling. This greatly improves the illumination of the ceiling, which is itself a very important light-giver. The lower part of the windows is not of so much consequence. It is desirable that they should not be so low as to let in light full upon the face horizontally. If the sill is placed four feet from the floor, no serious loss of light occurs. It is usually stated that if the surface of window-glass is calculated, it should amount to from $\frac{1}{5}$ to $\frac{1}{6}$ of the floor surface. Of course this depends somewhat on the locality. In order to secure the required amount, one side of the room must be made as full of windows as is consistent with the strength of the wall. The tint of the walls should be a neutral shade of blue, quite light. In general, paper is less cleanly than a hard finish.

Blinds should keep out the sun, and admit light and air. They are often poorly made; the rolling slats get out of order. They should be of a light color; natural wood color changes to a dark brown in time, but a light green tint is very pleasant, and admits a sufficiency of light when the sun is shining on the blinds. Solid shutters are not suitable. Curtains ought to be provided. The kind which rolls from the bottom is best, for it cuts off the horizontal light, which is often very annoying to the teacher as well as the scholars, while it leaves the upper part of the window free. If it is thought best to place any windows in the rear end of the room, they should be provided with these shades. Or the windows in that situation may be placed at the height of six or eight feet from the floor.

Projecting "architectural features," as cornices and pillars, are not to be allowed to interfere with windows, or lessen the amount of light entering. Windows must be square at the top.

VI. SCHOOL-DESKS AND GYMNASTICS

Some additional points are here to be given:

1. Support for the feet. This needs special attention in the case of little children. Wooden foot-rests ought to be given when needed.

2. Curves adapted to the body. The seat ought to be "curved," *i. e.*, hollowed. The back in American chairs is usually sloped so as to furnish an easy support in lounging. Some such chairs are so persuasive that one can hardly sit upright in them: this is a great fault, for the school ought to teach an upright carriage of the body. The chairs used in Germany, though the patterns vary greatly, are commonly made upon the principle of supporting only the lower half of the spine, usually by a

short, nearly upright, board. Many of our own chairs might be greatly improved by an approach to this pattern, the principle to be followed being this, that the back of the chair should fit the person closely at the lower part, where the spinal column needs support. I have seen a young lady in a high school suffering a good deal from pain due to the want of support at that point, which was relieved by placing a cushion there, behind the pelvis. No seat that can be devised is suitable for long continued occupancy by healthy children. Their bodily growth is impaired, and deformity is caused by the mere want of bodily activity. A cure for the crooked spine is not, therefore, to be had by carefully adjusting the size of the desk to that of the seat, and by giving the appropriate curves to the latter, but by developing the whole muscular system so that due support shall be given by nature. The deformities which come from this source are more frequent than is thought. Feeble, pale, quiet, over-dressed, a class of girls passes you, "filing" from room to room. You see one in a dozen with rosy cheeks, evidently a country girl. Their shoulders are all round, and they have the droop forward which indicates a want of muscular vigor and deficient expansion of the chest. A part of the impression thus given may be due to the subdued tone and manner of the school-room. The same girls, however, "stay in at recess;" they ride home in the horse-car; their leisure is spent in piano practice, and in going to parties.

There is a potent remedy for these evils in the hands of school boards: it is the practice of gymnastics. In this single measure the entire list of evils called "school maladies" is attacked by giving increased force to the entire physical system. Let pupils in normal schools be first made to appreciate the benefits of the system by applying it to them; let them learn to discard sundry superfluities of dress, by being taught the comforts of "gymnasium dress;" let plain sense, under the title of hygiene, be taught as more important than scientific physiology. If this class of persons can be converted, a permanent benefit accrues to all their pupils in future.

But to return to the subject of desks:

3. In classes, however well graded, great differences of height are noticed. In accordance with this, each class-room in a graded school ought to have at least two sizes of desks; three are desirable.

4. Height of the desk. When the pupil sits upright, and the arms swing freely, the elbows will be just below the edge of the desk, and when bent in writing, will barely clear the edge. Girls require a desk from one half to three quarters of an inch higher.

5. The edge of the desk must come up to a line just over the edge of the seat, or must overlap the seat by an inch or two. This keeps the child from stooping.

Nos. 4 and 5 are of importance as tending to prevent deformity. Too high a desk raises the right or left shoulder unduly. A desk at a distance from the pupil's seat compels him to take a bad posture.

What remains to be said of school gymnastics may be said here. A

good deal may be done with no apparatus at all in the ordinary class-room. Light gymnastics, comprising movements of the arms, are to be practised daily, more for the benefit of the change and for stimulating circulation than for development of body. An hour twice a week will suffice for a more thorough course, with a trained special teacher, in a room devoted to the purpose. No heavy apparatus is recommended,—light wands, dumb-bells of wood, perhaps small clubs. It has been found best for classes exercising together in the Amherst college gymnasium to give up the heavy gymnastics altogether; much more so in schools. Then there are the "free exercises," including proper methods of sitting, standing, lying, walking, running, jumping, as well as exercises in concert, games, etc.

"The aim of these free exercises is to call into action in turn the greater part of the voluntary muscles of the body; and with an intelligent, earnest teacher to direct them, there is no end to the modifications and combinations that can be made, calling for precision, and strict attention, and skill on the part of pupils."[1]

A very valuable work can be done at once, with no special apparatus, and with comparatively little training, by heads of schools who have at command a spare room or a hall with movable seats. The members of upper classes can be instructed by him with perfect success in marching, facing, and a variety of exercises of too complicated a nature to be carried on in the school-room.

There are two present obstacles to the adoption of a complete system of training,—the expense, and the want of trained teachers. The calling of a gymnastic teacher, in fact, is a laborious one. But the matter is one of prime importance, especially in our city schools; and teachers may aid materially in securing the adoption of a thorough system by trying to use the means now in their power.

VII. AFFECTIONS OF THE NERVOUS SYSTEM.

School life is capable of doing much good, as well as harm, to the mental and nervous life of scholars. Over-work, work performed under pressure or at bad seasons of the year, work done in a state of anxiety, are among the causes of injury. The influence of competition for prizes is acknowledged to be bad in a great many cases.

"Double promotions" ought to be watched with care.

As regards over-work, a change in public feeling has come about of late, which has largely led to the abandonment of home study for pupils under the age of (about) twelve years, and has cut down the hours of attendance at school to five in the day. One innovation of modern origin requires to be criticised,—the use of a single session, closing at 1 or 2 P. M., instead of the morning and afternoon session. There should be one long recess in such a session, and arrangements for luncheon may

[1] Dr. J. J. Putnam.

enter with profit into the consideration of the school authorities, for it is unnatural for a growing youth or girl to fast six hours on a stretch amidst vigorous exertion of mind. The fact that some have no appetite for a lunch constitutes ground for suspecting that the school life or work is responsible for the want of appetite.

It is a serious grievance of teachers and scholars that the time of year when the work is hardest is the spring and early summer, the season alike of review, examinations, diplomas, promotions, prizes, all of which is made more trying by "spring sickness" and premature summer heats. At the close of a year's work there should be an approach to relaxation of effort. How difficult it is to secure such a relaxation is well known to teachers. Many a teacher is ready to faint with fatigue before the welcome rest comes. The children do not now suffer so much, their work being rather irregular than severe, for the most part, at those times.

On a matter so familiar to the public as mental over-work and strain among school-children, not a great deal need be said. It is probable that social dissipation does a great deal more harm than school work. Girls, of course, need more watching than boys, for they more readily give up their habits of out-door exercise, and too often have no in-door work whatever to compensate for it. Even among teachers this fault is marked. Their toil is an anxious one, and they require relaxation as much as any profession, but they too often fail to recognize the need. The writer was told by a prominent "kindergarten" teacher, who has teachers under her and instructs others in kindergarten work, that it is a frequent fault among her teachers, as well as her adult pupils, to suppose that they could work in the morning in teaching, attend a class in the afternoon, and go to parties in the evening, the fact being that in this kind of work no teacher ought to consider herself capable of any serious, responsible undertaking outside of her kindergarten; and the kindergarten hours are from *nine* to *twelve* o'clock!

Without doubt this is very near the truth. Teachers who have five hours' work a day are to be considered as having done a day's work. Seldom, however, is the work completed in that time, for under the new regime a great deal of work is written by the children, and has to be looked over and corrected at home by teachers.

Among positive injuries to the system, and symptoms of injury, the following may be named as often due to school fatigue:

Debility, want of appetite, dyspepsia, sleeplessness, irritability, headache. Other troubles, of less frequent occurrence, are menstrual anomalies, irritable spine, hysteria, chorea, neuralgia. A case of epilepsy is known to the writer, which recurred after five years of health, in a vigorous youth who overworked himself in competing for a prize in *gymnastics*.

Complaints peculiar to females have often been charged to the injury received in going up and down stairs. Derangement, including excess, painful periods, or deficiency, as well as local displacements, have been

noticed. It is certain that the existence of many flights of stairs is complained of, and that young women avoid rooms in the upper stories of boarding-schools in many cases. It may be well to give here a summary of the evidence collected by Geo. E. Smith, M. D., in 1874, in respect to a number of such institutions. The replies amount to the following, substantially:

Answer No. 1. The complaints named are not usually prevalent: there are restrictions upon undue haste in going up or down stairs: should prefer to have no dormitories above the second story.

2. They are very frequent, and are due to this cause.

3. High buildings are bad if there is carelessness in running up and down, not otherwise; improper dress and dissipation are the chief causes.

4. Similar to 3.

5. Rarely due to stairs; due to dissipation: should prefer two-story buildings.

6. Not due to stairs, but to lacing, heavy skirts, and over-work.

7. Dress, corsets, and stair-climbing are far more to blame than study.

8. Stairs are a great evil while girls are dressed as they are now.

The matter has been touched upon in another division of this essay.

VIII. CONTAGIOUS DISEASE IN SCHOOLS.

The diseases intended by the title are diphtheria, scarlet fever, measles, and small-pox.

There is little need to enforce by argument the importance of the subject. There is a pretty general feeling that the matter of complaint is not an imaginary one. In the report of the Massachusetts State Board of Health (ninth) a large number of letters from physicians are cited or referred to, all, with scarcely an exception, acknowledging the danger of contagion to be real. There is, however, a mass of ignorance and blindness in the lower social strata which cannot be expected to pay the slightest heed to ordinary precautions for preventing contagion until forced to do so. The means for bringing such heedless persons to their duty now exist in many places in the form of local ordinances or school regulations. Such regulations should be something like the following:

1. The existence of a case of the above named diseases should exclude from school all inmates of the house in which it prevails, until competent authority decides that it is safe for them to return to school.

2. Teachers, school officers, or physicians should report cases coming to their knowledge at once, whether such cases are in their own school or not. The child affected is to be sent home at once, and the parents informed of the law.

3. Contagion being easily spread by pupils after recovery by means of clothing or fine particles of epidermis, etc., it is necessary to establish rules for disinfection, whether of the premises and clothing, or of the patient's body, the proper performance of such disinfection, and the lapse of a suitable time, being ascertained upon good authority.

4. Evidence of vaccination should be required of all children entering the public schools, and revaccination should be recommended to pupils at a later date, especially during epidemics of small-pox.

Contagious affections of the skin, and spasmodic diseases (itch, scald head, ring-worm, epilepsy, St. Vitus's dance, habitual hysteric attacks), are deserving of attention, as liable to occur at any time in a city school. Teachers should have some knowledge of what is to be done in such cases, and should be authorized to complain to school governments. The convulsive affections named are, some of them, contagious through imitation, and must be excluded unless there seems good reason for the contrary course.

IX. SANITARY SUPERVISION.

As a corollary to all that has been said, we must consider how the facts can be made operative in and upon the schools. In many school boards, one person—or a committee—is charged with matters pertaining to the health of scholars. For most places this plan is the desirable one. In large places, including cities of all sizes, a natural means to this end is the appointment of one or more persons charged with the enforcement of regulations based on sanitary principles. This plan will soon be tested thoroughly; the only difficulty (or rather, the only question) seems to be in relation to the extent of the duties and functions of such officers.

The cities of Elmira, N. Y., and Boston, Mass., each have an officer, a physician, who acts as medical supervisor. In the latter place he is entitled "Instructor in Hygiene," the peculiarity of the designation being due to certain technical difficulties in the local statutes. Here it may be truly said that the field for one man's exertions being unlimited, and far beyond any man's capacity to fill, it is open to the incumbent's discretion to select the most necessary objects for his first attention. At present the inspection of the buildings forms the leading object in Boston. Instruction in hygiene is also given by means of lectures addressed to teachers. That such an officer should be a physician requires no proof.

How great the opportunity for work may be in certain cases is shown by that of the city of Brussels, which (for European ideas) presents a model in this respect. This city, with a population of 183,000 and thirty-three public schools, has a staff of medical visitors sufficient in number to make a *weekly* visit, with personal attention, to each pupil. In one respect their duties go beyond what is likely to be thought advisable in America at present,—they give medical treatment to a large number of pupils at school. The number thus treated for the three years 1876–'79 was 446, 732, 1,118, besides which, during the same three years, there were 2,885 cases of dental treatment. Among the chief duties of such an officer should be those of inspection of buildings, and of instruction of teachers in the principles of hygiene as applicable to their charges. Sanitary rules may be proposed by him, and he will have a great opportunity of rectifying errors in sanitary administration due to mere ignorance. He will not take from members of the school board their right to be

interested, but he can greatly increase the interest if he knows how to use his knowledge of the subject. It need not be said that there are some points where the field is already occupied, as the matter of public vaccination, and other means for guarding against contagion—matters usually in the hands of town or city boards of health. Where these points are not thus arranged, the school inspector should have them in charge.

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